

Federal Diesel Research Study

**September 25, 2009
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California Environmental Protection Agency



Air Resources Board

Overall Program Plan

- Test matrix includes 3 fuels
 - CARB, Federal A, and Federal B
- Testing of 3 engines
 - 2007 MBE4000, 2006 Cummins ISM, 1991 DDC 60
- Chassis dyno testing
 - 10 trucks including 3 CARB vehicles
 - Testing focuses on CARB 50 mph Cruise cycle

Engine Testing Status

- Fuel Analyses in Process (cetane remains)
- Testing on 2007 MBE4000 completed
 - Results discussed in presentation
- 2006 Cummins ISM completed (9-21-09)
- Testing 3rd engine to follow
- Memorandum on engine testing completed by Nov/Dec 2009

Analysis of Test Fuels

Results and Comparison with
Approved Property Ranges

Consistency of test fuel properties known to effect NO_x emissions

- Aromatic Hydrocarbon Content

- ✓ CARB < Fed. A < Fed. B

- API Gravity

- ✓ CARB > Fed. A > Fed. B

- Cetane Number

- ✓ CARB > Fed. A > Fed. B

- T50

- ✓ CARB < Fed. A < Fed. B

Chassis Dyno Status

- Chassis dyno testing in 1st Quarter of 2010
 - Construction planned for Nov/Dec 2009
 - Commissioning January 2010

- 10 test vehicles
 - Trucks with 2007 MBE4000 and 2006 Cummins
 - CE-CERT's in-house truck with 2000 Caterpillar engine
 - Port indicated they could provide additional vehicles
 - Port indicated they could provide additional vehicles

Engine Parameters

- 2007 MBE4000
 - Equipped with OEM DPF
 - In-line, 6 cylinder, 4-stroke, 12.8 L engine
 - 410 hp @ 1900 rpm
 - Turbo charged with EGR

Engine Parameters

- 2006 Cummins ISM 370
 - In-line, 6 cylinder, 4-stroke, 10.8 L engine
 - 370 hp / 1450 ft-lbs @ 1200 rpm
 - Turbo charged with EGR
- 1991 Detroit Diesel Series 60
 - In-line, 6 cylinder, 4-stroke, 11.1 L engine
 - 350 hp @ 1800 rpm
 - Turbo charged with aftercooler

Engine Dyno Test Matrix

Test Day				
Heavy-Duty FTP Test Cycle				
Day 1	CCC	AAA	AAA	BBB
Day 2	BBB	CCC		
ARB HHDDT Cruise Test Cycle				
Day 2			CCC	AAA
Day 3	AAA	BBB	BBB	CCC

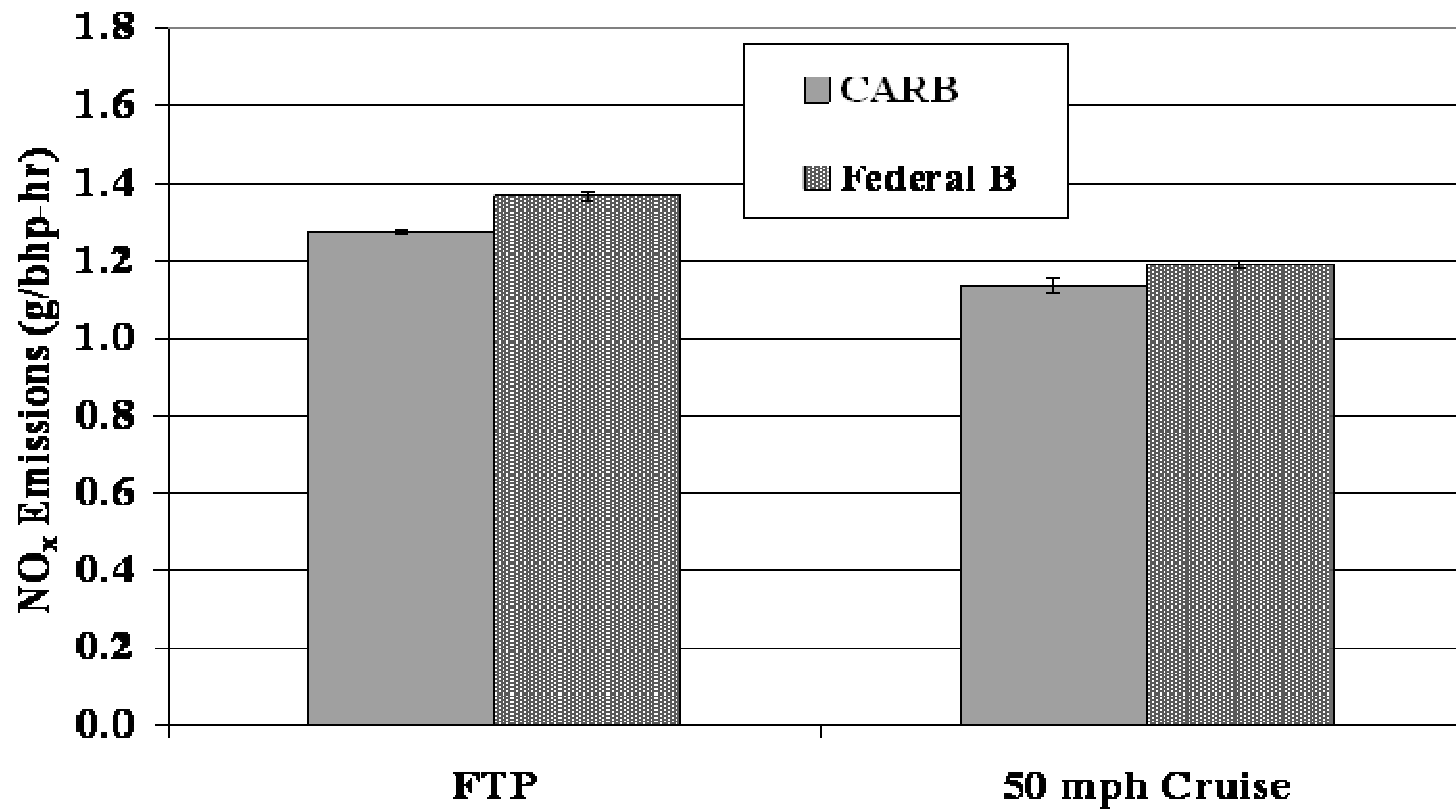
C = CARB diesel fuel, A = Federal A diesel fuel, B = Federal B diesel fuel

2007 MBE4000 Results

- NO_x emissions were higher for the Federal B fuel compared with the CARB fuel
- PM, THC, and CO emission levels low and the differences between the fuel were either not statistically significant or were small
- CO₂ increased slightly for Federal B
- Fuel consumption slightly higher for Federal B fuel

NO_x Results 2007 MBE4000

NO_x Emissions

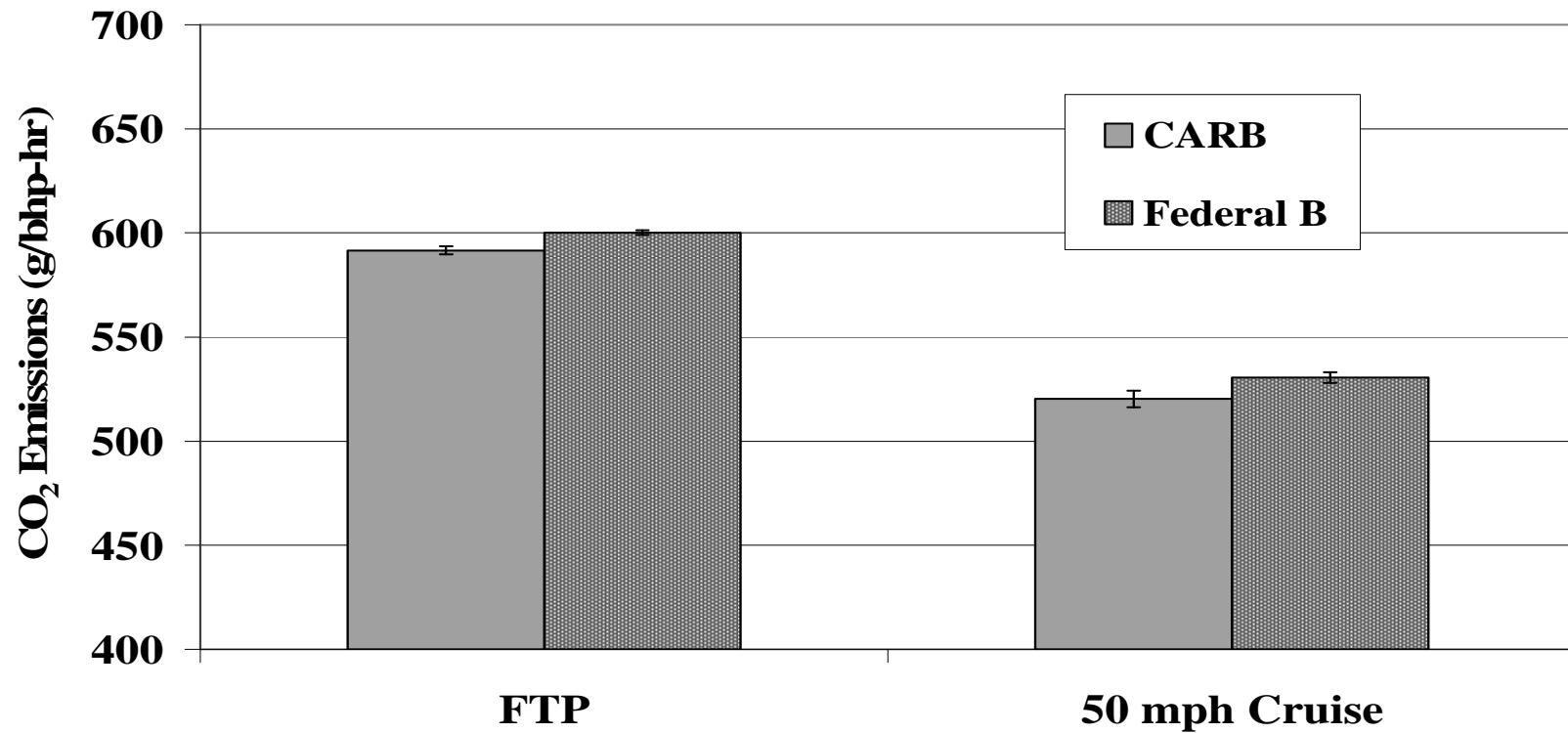


NOx Results 2007 MBE4000

		2007 MBE4000	
	CARB vs.	% Difference	P-values
FTP	Federal A	-	-
	Federal B	7.3%	0.000
50 mph Cruise	Federal A	-	-
	Federal B	4.7%	0.000

CO₂ Results 2007 MBE4000

CO₂ Emissions

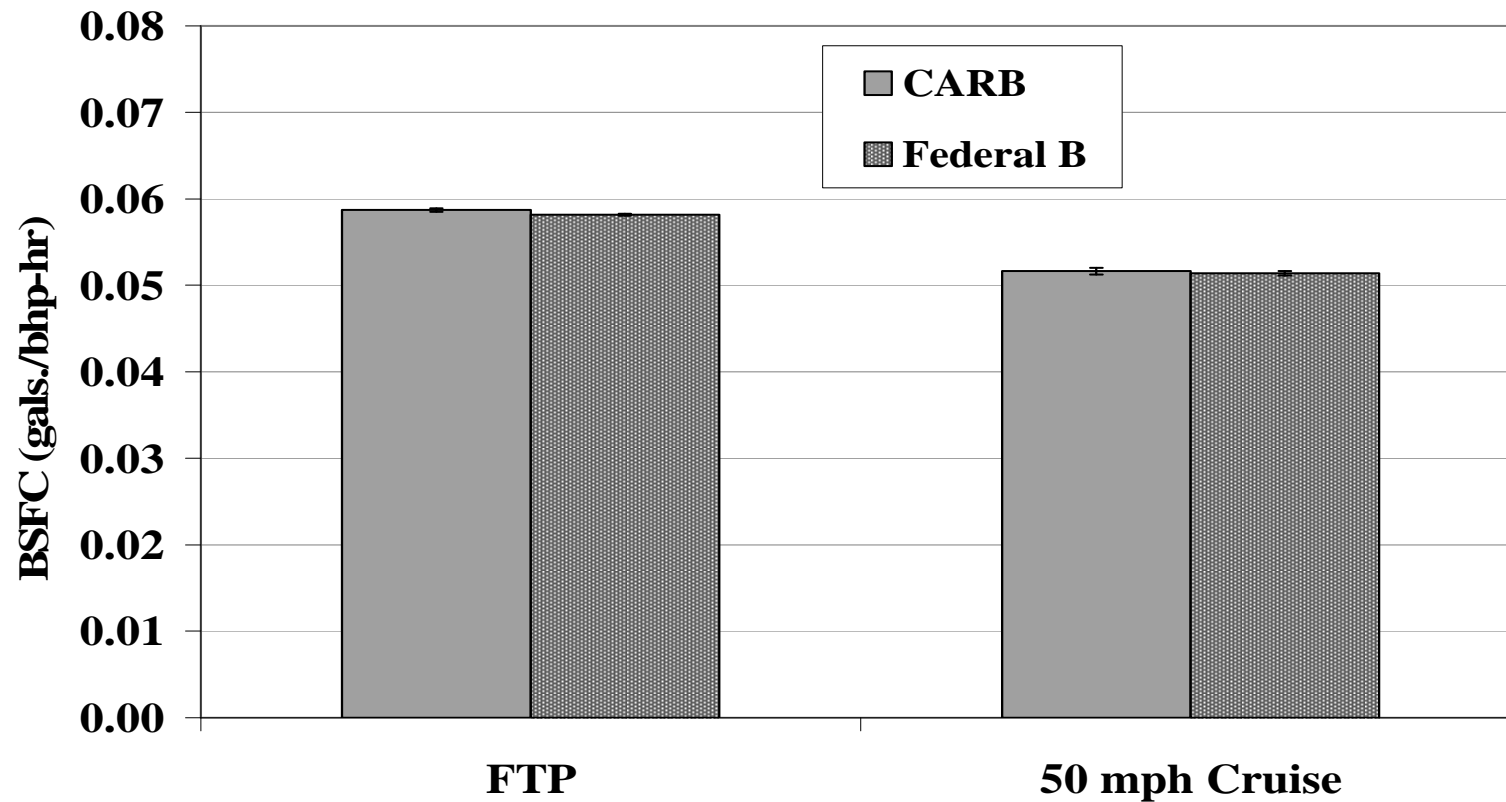


CO₂ Results

		2007 MBE4000	
	CARB vs.	% Difference	P-values
FTP	Federal A	-	-
	Federal B	1.4%	0.000
50 mph Cruise	Federal A	-	-
	Federal B	2.0%	0.000

BSFC Results 2007 MBE4000

BSFC



BSFC Results

		2007 MBE4000	
	CARB vs.	% Difference	P-values
FTP	Federal A	-	-
	Federal B	-0.9%	0.000
50 mph Cruise	Federal A	-	-
	Federal B	-0.4%	0.255